Table 7: Long-Run Economic Impact Estimates, Summary Table

	Mean	80% Confidence Interval	
		Lower Bound	Upper Bound
Total Long Run Jobs	38,603	26,478	53,130
Total Long Run Direct Jobs	20,836	14,284	28,673
Total Long Run Indirect and Induced Jobs	17,766	12,165	24,581
Total Long Run Earnings, $Million	$2,033	$1,334	$2,912
Total Long Run Direct Earnings, $Million	$1,073	$706	$1,536
Total Long Run Indirect & Induced Earnings, $Million	$960	$889	$1,380
Incremental New Area Households	17,267	12,116	23,848
Total Long Run Impact, $Million	$3,096	$2,042	$4,424
Present Value of Total Long Run Impact, $Million	$818	$540	$1,169

Figure 4: Long-Run Employment Impacts from Antelope Valley Alignment

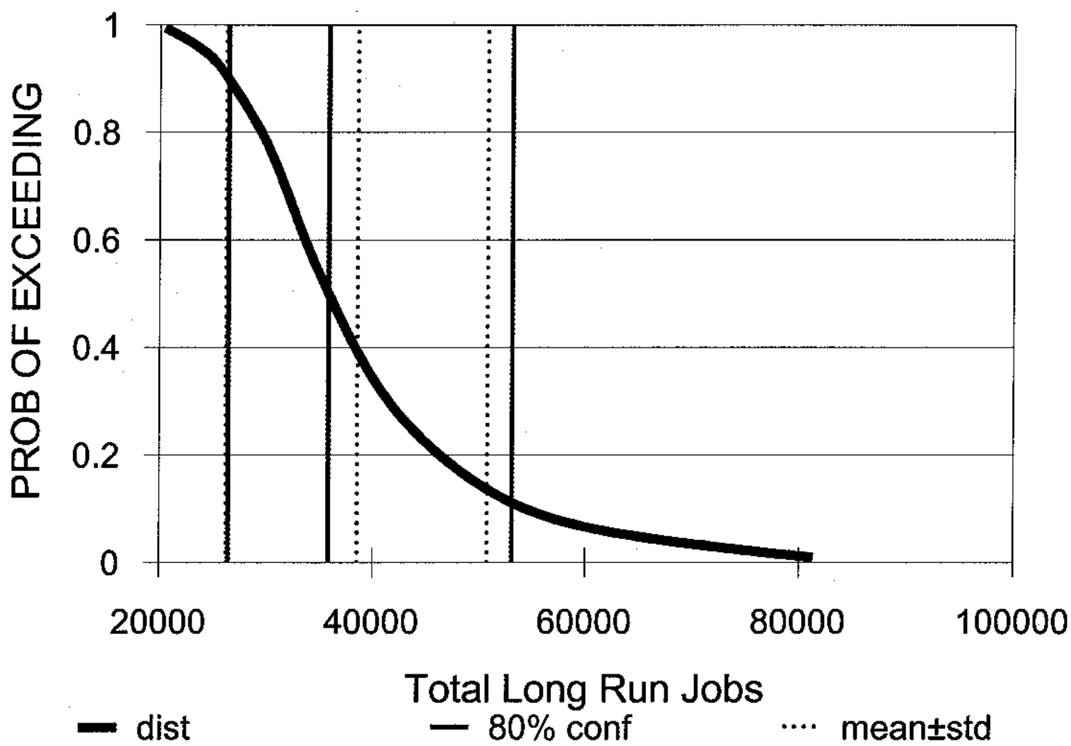


Figure 5: Long-Run Earnings Impacts from Antelope Valley Alignment

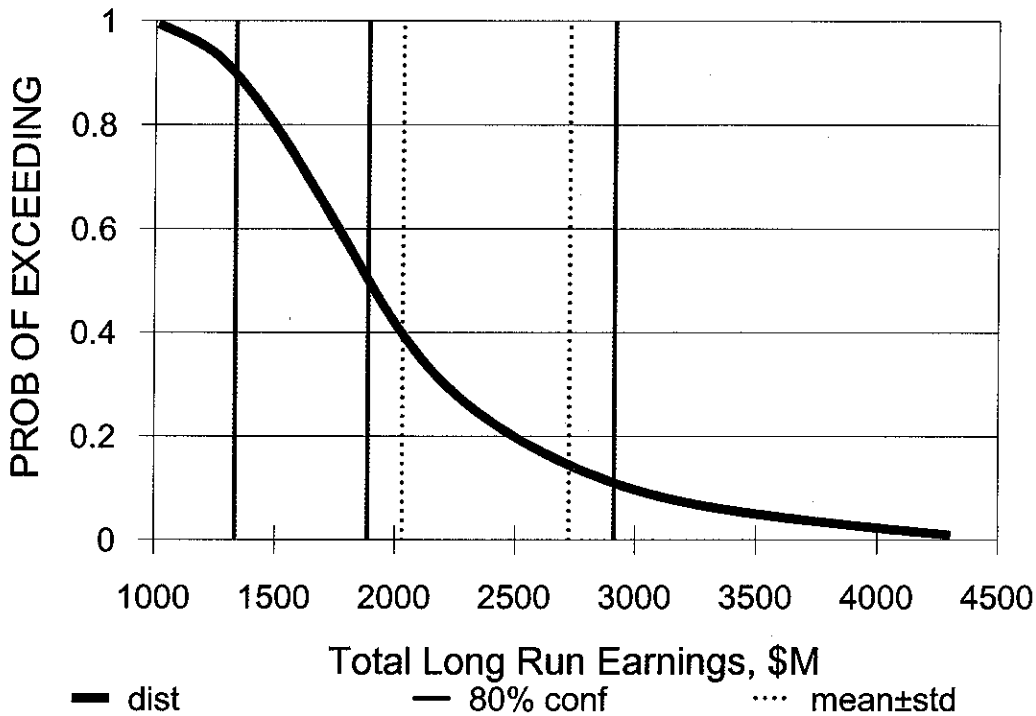
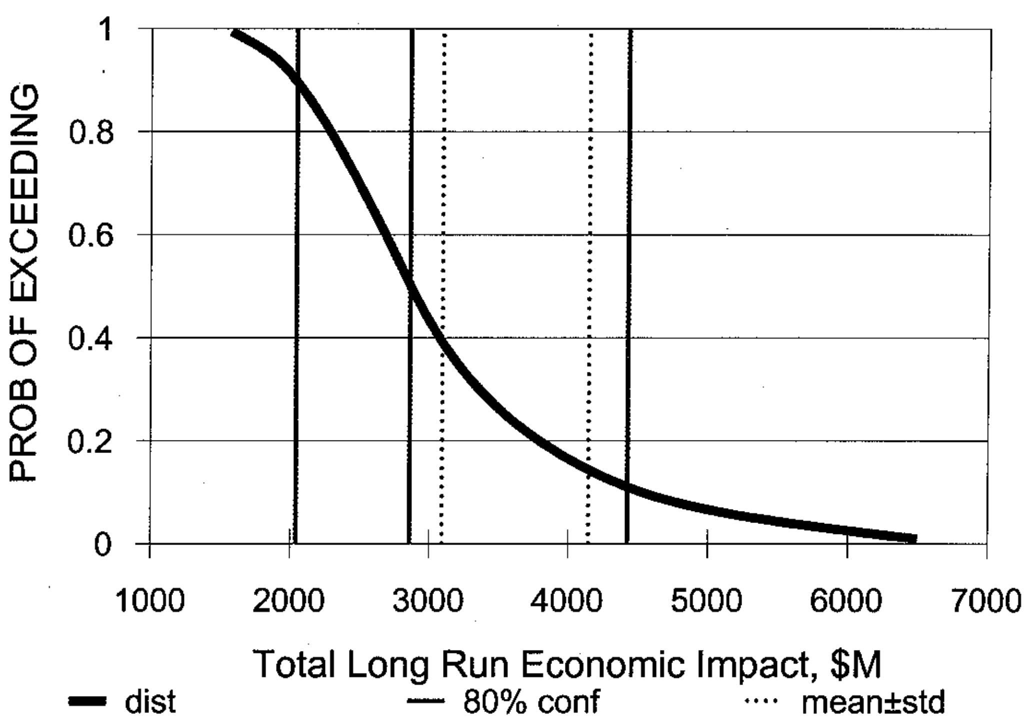


Figure 6: Total Long-Run Economic Impacts from Antelope Valley Alignment



3.4 Summary of Findings and Conclusions

One of the factors supporting the Antelope Valley alignment is the potential for high-speed rail to generate significant long-term economic development impacts. The economic, demographic and physical characteristics of the Antelope Valley community are poised to take advantage of HSR-based economic development activity in the state of California. Based on interviews[14] of the largest housing developers in California to determine the impact of HSR on housing, an HSR system through the Antelope Valley would be of great benefit because of the quick access to major cities, north and south of the valley. The developers stressed that capital expenditures involved in the construction and operation of the HSR will also stimulate the Southern California economy and that Antelope Valley would be a natural location to accommodate future population and housing growth in California.

The estimation in this chapter considers the high-speed rail's contribution in attracting individuals and families to the Antelope Valley, which is one of the few regions in the greater Los Angeles area, which can support residential and industrial growth. It was found that, under conservative assumptions, the economic development potential from high-speed rail in the Antelope Valley is about $3 billion over thirty years. It is clear, that the economic impact alone outweighs the possible increase in capital costs.

[14] ERA "Economic Impact and Benefit/Cost of High Speed Rail for California, Final Report", September 1996.

4. ECONOMIC VIABILITY

This chapter presents the results of a detailed benefit-cost analysis of the Antelope Valley and the Grapevine high-speed rail alignments. After a brief description of the nature, tools and limitations of benefit cost analyses in the first section, Section 3.2 summarizes the principal assumptions made to carry out the analysis. Estimates of user and nonuser benefits are presented in Section 3.3 while Section 3.4 explores the costs associated with the two alignments. Finally, Section 3.5 concludes the chapter with the estimation of a set of standard evaluation criteria: net present value, internal rate of return and benefit/cost ratio.

4.1 A Primer on Benefit Cost Analysis

The primary purpose of conducting a benefit cost analysis in this study is to compare the economic worth of alternative alignments.

4.1.1 Economic Benefits and Economic Impacts

Whereas economic impact analyses are typically concerned with changes in output, profits, value added, or jobs (See Section 3.1.), economic benefits as defined in this chapter, refer to the benefits that individual "users" (and "nonusers") of a particular facility or service may enjoy. In the present study, economic benefits include (but are not limited to) the monetary value of (or "willingness-to-pay" for) travel-time savings, safety savings, or environmental savings associated with the construction of high-speed rail in the State of California.

4.1.2 An Aid for Decision Making

The primary purpose of a benefit cost analysis is to aid decision-making by comparing the total benefits to the total costs of implementing a project, program or policy. There are several applicable "tests" for this decision-making analysis[15]:

Feasibility: A project is "feasible" if there is the money and technical resources to do it. This test, by itself, is applicable if there is a desire to do the project regardless of resource costs -- a rare circumstance.

Cost Effectiveness: This is the ratio of cost per unit of desired results (e.g., cost per ton of emissions reduction, or cost per person served). This test is applicable when the benefit measure cannot be reliably translated into money terms (e.g., pollution reduction). It is most usefully applied when there is a clear goal (measure) for the desired level of benefit results.

Net Present Value (NPV): This is calculated as follows:

NPV = Present Value of Project Benefits minus the Present Value of Project Costs, where the Present Value is the discounted value of a stream of benefits or costs (as explained below).

[15] This part draws heavily from Weisbrod, Glen and Burton Weisbrod, " Measuring Economic Impacts of Projects and Programs," *Economic Development Research Group*, April 1997.

The Net Present Value reflects the value of the project at the time of decision-making. At its best, the NPV test can be the most comprehensive form of economic comparison, encompassing the money values of all favorable effects (benefits) and all unfavorable effects (costs). Any project with a positive NPV is said to be "efficient." Among competing projects, the alternative that maximizes NPV is also the most desirable one, i.e. the most "economically efficient" one.

<u>Benefit/Cost Ratio (B/C)</u>: This is calculated as follows:

B/C = Present Value of Project Benefit divided by Present Value of Project Cost

By definition, any project with a positive NPV will also have a B/C ratio exceeding 1. However, a large project with lower B/C ratio (e.g., 1.4) may still have a higher NPV than a small project with a higher B/C (e.g., 1.6). For agencies with constrained funding resources, the B/C test is thus the preferred basis for decision-making among alternatives (such as the choice of project size, location or configuration). While in theory, any project with a B/C ratio exceeding 1 is worthwhile, most public agencies have recognized that there is some uncertainty associated with both the benefit and the cost estimates. Accordingly, it is not uncommon for agencies to desire a threshold of B/C exceeding 1.5 for large new projects, and 1.3 for incremental projects (in which uncertainty is less.)

<u>Calculation of "Present Value"</u>: Both NPV and B/C tests require that costs and benefits be presented in terms of their value as of the time of the decision-making. This involves a two-step process. First, all costs and benefits must be expressed in constant dollars (which effectively controls for future inflation). Then, a discount factor is applied to reduce the values of future costs and benefits to represent their present values. The formula is as follows:

Present value of a dollar of cost or benefit in a future year (n) = $1 / (1 + d)^n$

where d is the discount rate (i.e., the time value of money over and above inflation)

Selection of the appropriate discount rate is an important and sometimes controversial policy issue. The lower the discount rate selected, the more likely will be that projects with high initial costs but benefits far off in the future will pass the NPV and benefit/cost tests. The principal criterion is the "opportunity cost of capital", which may be judged to be any one of the following:

- The rate of return that the money can could have otherwise earned in the private sector; or
- The actual cost of borrowing money by a public sector agency (which is typically a low interest rate due to its tax free status); or
- The rate at which people effectively value receiving money now rather than in the future (the "social rate of time preference").

4.2 Input Assumptions and Methodology

Most of the input assumptions necessary to carry out the analysis follow from the Authority' 1999 memorandum "Business Plan Benefit/Cost Analysis of the California High-Speed Rail System." These assumptions are summarized in Table 8 below.

Table 8: Benefit Cost Analysis Inputs

Variable Name and Description	**Value**
Real Discount Rate	4.00%
Trip Purpose Shares by Mode (Los Angeles - San Francisco)	
Air	50.0%
Rail	28.0%
Private Vehicle	16.6%
Value of Auto-Travel Time	
Business	
Short Distance (Less than 150 miles)	$20.83
Long Distance (150 miles or more)	$27.93
Non-Business	
Short Distance (Less than 150 miles)	$6.83
Long Distance (150 miles or more)	$14.88
Auto Occupancy (persons per vehicle)	
Business	1.90
Non-Business	2.60
Accident Costs	
Cost per VMT (1999 Dollars)	$0.0599
Air Pollution Costs	
Cost per VMT (1999 Dollars)	$0.0079
Project Timing	
Opening to the Public	FY 2017
Planning and Engineering Costs start in	FY 2001
Heavy Capital Costs	FY 2007
Operating, Maintenance & Rolling Stock Acquisition or Replacement	FY 2050
Percent Diversion to HSR	
Air (Local)	37.4%
Air (Connect)	3.7%
Rail	83.3%
Private Vehicle	4.9%
Sources of HSR Ridership	
Air	37.8%
Rail	8.4%
Private Vehicle	46.5%
Induced Demand	7.3%

All benefit estimates presented in this report[16] are based on ridership and passenger revenue projections developed by the Authority, adjusted by risk analysis factors in accordance with Sections 1.1 through 1.3 of this report. All cost estimates are based on Parsons Brinckerhoff 's July 1999 cost projections adjusted by risk analysis factors in accordance with HLB's own assessment of construction cost risks (See Chapter 4 of this report).

4.3 Benefit Estimates

Four rider markets should be considered in the estimation of the benefits associated with a HSR system: intercity travelers, urban travelers, freight-shippers and travelers to and from California's airports (including interstate and international travelers). A distinction between business and non-business travelers is also needed, since business travelers have a significantly higher value of time, in particular.

The benefit estimates presented on this report are based on the Authority's methodology and projections. Since no independent ridership forecasts for airport-related travel were available, it was not possible to derive the revenue and benefits associated with that segment of the market. They were included in the estimates for intercity travel instead. Similarly, given the lack of precise statistics on the volume of freight between Californian cities, HLB chose not to include its own estimates of user benefits associated with that market into the computation of the evaluation criteria.[17] Finally, the nonuser benefits associated with intercity travel exclude the nonuser benefits generated in the Los Angeles, San Francisco and San Diego metropolitan areas. The nonuser benefits associated with urban travel include the intercity nonuser benefits within these areas.

All benefit estimates are expressed in present value, i.e. as the discounted value of the stream of benefits over the lifetime of the project, from start of fiscal year 2017 to end of fiscal year 2050. A 4% real discount rate is assumed.

4.3.1 Benefits to High-Speed Rail Users

Potential users of high-speed rail would be the primary beneficiaries of the project. They would experience extensive travel time and safety savings, as well as other benefits associated with the comfort and reliability of high-speed trains. The benefits associated with each of the markets identified in the introduction of this section are presented below.

4.3.1.1 Intercity Travel

Travelers from a major metropolitan area to another would be "willing-to-pay" an approximate $8.5 billion or $320 Million a year (estimated in year 2020) on top of the HSR fare, for the services offered by both high-speed rail alignments. Most of these "benefits" would stem from reductions in travel time that high-speed trains would allow relative to private vehicles.

[16] Associated with the Intercity and Commuter markets.

[17] See Appendix 5 for freight statistics and HLB estimates of the HSR benefits to freight shippers.

Table 9: Intercity Travel, HSR User Benefits, Most Likely Value

	Antelope Valley	Grapevine
Intercity Passenger Revenue	**$9,718**	**$9,651**
User Benefits		
Travel time savings		
Business	$4,113	$4,226
Non-Business	$2,519	$2,589
Total	$6,633	$6,815
Safety savings		
Business	$511	$480
Non-Business	$850	$798
Total	$1,361	$1,278
Quality of Service		
Business	$176	$160
Non-Business	$292	$266
Total	$468	$426
Total Benefits to HSR Intercity Travelers	**$8,504**	**$8,519**

All estimates in Present Value, 1999 Dollars

4.3.1.2 Urban Travel

Even though the contribution of commuter travel to total passenger revenue would be limited, significant user benefits could be expected from the use of high-speed rail alignments for commuting purposes. Again, most of the benefits would stem from reductions in travel time and accident costs.

Table 10: Urban Travel, HSR User Benefits, Most Likely Value

User Benefits	Antelope Valley	Grapevine
Travel time savings	$280	$253
Safety savings	$53	$48
Quality of Service	$18	$16
Total Benefits to HSR Urban Travelers	**$350**	**$317**

All estimates in Present Value, 1999 Dollars

4.3.1.3 Total High-Speed Rail User Benefits

Total high-speed rail user benefit estimates are summarized in Table 11 below. The table shows the mean estimate and the 80% confidence interval indicating the range of likely variations for total user benefits. The last row of the table indicates whether the difference observed between the two alignments is statistically significant, i.e. whether one alignment is superior to the other given the risks associated with the ridership forecasts.

Table 11: Risk Analysis of HSR User Benefits

	Mean	80% Confidence Interval	
		Lower Bound	Upper Bound
Antelope Valley Alignment	8,854	8,309	9,419
Grapevine Alignment	8,799	8,573	8,990
Percentage Difference	0.6%	-3.1%	4.8%
Is the Difference Statistically Significant?	No		

The HSR alignment through the Antelope Valley would generate slightly more user benefits (net of fare-box revenue). The difference, however, is not significantly different from zero. Why? Although the Antelope Valley alignment would produce more ridership, intercity riders traveling through the Tehachapi crossing would have to spend slightly more time on the train, i.e. would enjoy slightly less travel-time savings. Therefore, the extra benefits brought about by the increase in ridership would be partly offset by the reduction in travel-time savings that each rider would enjoy. All in all, user benefits under the Antelope Valley alternative are larger than under the Grapevine alternative but to a lesser extent that one could expect from looking at the ridership and revenue forecasts.

4.3.2 Benefits to Non High-Speed Rail Users

Benefits to non high-speed rail users are "derived" benefits. They arise from the diversion of travelers away from existing transportation modes (primarily air and private vehicle) to the new HSR mode, and from the associated reduction in congestion on the existing modes. This reduced congestion implies, in particular, improved speed along California's highways[18] and reduced delays at California's airports.

4.3.2.1 Intercity Travel

Estimates for nonuser benefits accruing to intercity travelers and stemming from the diversion of intercity and commuter travelers away from California's highways and California's airports are summarized in Table 12 below. Again, most of the benefits would be in the form of travel-time savings although significant operating cost, accident cost and air pollution savings are expected as well.

[18] The analysis is restricted to highway travel.

Table 12: Intercity Travel, Non HSR User Benefits, Most Likely Value

Non HSR-User Benefits	Antelope Valley	Grapevine
Benefits to Highway Users		
Travel time savings		
Business	$1,035	$971
Non-Business	$2,737	$2,569
Total	$3,772	$3,540
Safety savings		
Business	$130	$129
Non-Business	$652	$651
Total	$782	$780
Total Benefits to Highway Users	**$4,554**	**$4,320**
Benefits to Air Travelers		
Travel time savings		
Business	$6,655	$6,415
Non-Business	$1,400	$1,349
Total	$8,055	$7,765
Aircraft operating cost savings		
Business	$2,211	$2,141
Non-Business	$2,211	$2,141
Total	$4,422	$4,283
Total Benefits to Air Travelers	**$12,476**	**$12,048**
Environmental Benefits *	**$103**	**$103**
Total Non HSR-User Benefits (Intercity Travel)	**$17,133**	**$16,471**

* *Associated with Intercity Travel*

4.3.2.2 Urban Travel

The diversion of commuters and intercity travelers away from commuter/urban roads would help relieve severe congestion problems. Again, travel-time savings and safety savings would account for most of the benefits, as shown in Table 13 below.

Table 13: Urban Travel, Non HSR User Benefits, Most Likely Value

Non HSR-User Benefits	Antelope Valley	Grapevine
Benefits to Highway Users		
Travel time savings	$9,817	$8,822
Safety savings	$360	$326
Total Benefits to Highway Users	**$10,178**	$9,149
Environmental Benefits	**$48**	$43

Total Non HSR-User Benefits (Urban Travel)	$10,225	$9,192

Given the strategic position of the Palmdale station in North L.A. county, the Antelope Valley alignment is expected to generate significantly more benefits to urban travelers than the competing alignment.

4.3.2.3 Total Non High-Speed Rail User Benefits

Table 14 summarizes the risk analysis of total nonuser benefits. Again, the statistical significance of the difference between the two alignments is evaluated on the basis of Monte Carlo simulation results. It appears that under the assumptions presented in Section 3.2, total nonuser benefits, when estimated at the median, would be significantly larger under the Antelope Valley alternative.

Table 14: Risk Analysis of Non HSR User Benefits

	Mean	80% Confidence Interval	
		Lower Bound	Upper Bound
Antelope Valley Alignment	27,359	25,825	29,107
Grapevine Alignment	25,556	24,901	26,111
Percentage Difference	7.1%	3.7%	11.5%
Is the Difference Statistically Significant?	Yes		

4.4 Indicators of Economic Viability

As explained in Section 3.1, various "tools" are available to assess the relative value of two or more investment alternatives: the Net Present Value, Benefit Cost Ratio and Internal Rate of Return are among the most commonly used.

4.4.1 Net Present Value

As Table 15 indicates, the Net Present Value of the HSR project would be significantly larger under the Antelope Valley option.

Table 15: Net Present Value Estimates

	Mean	80% Confidence Interval	
		Lower Bound	Upper Bound
Antelope Valley Alignment	23,621	21,123	26,384
Grapevine Alignment	22,448	21,431	23,385
Percentage Difference	5.3%	-1.4%	12.8%
Is the Difference Statistically Significant?	Yes		

The decumulative probability distribution for the Net Present Value of the project under both alignments is shown in Figure 7.

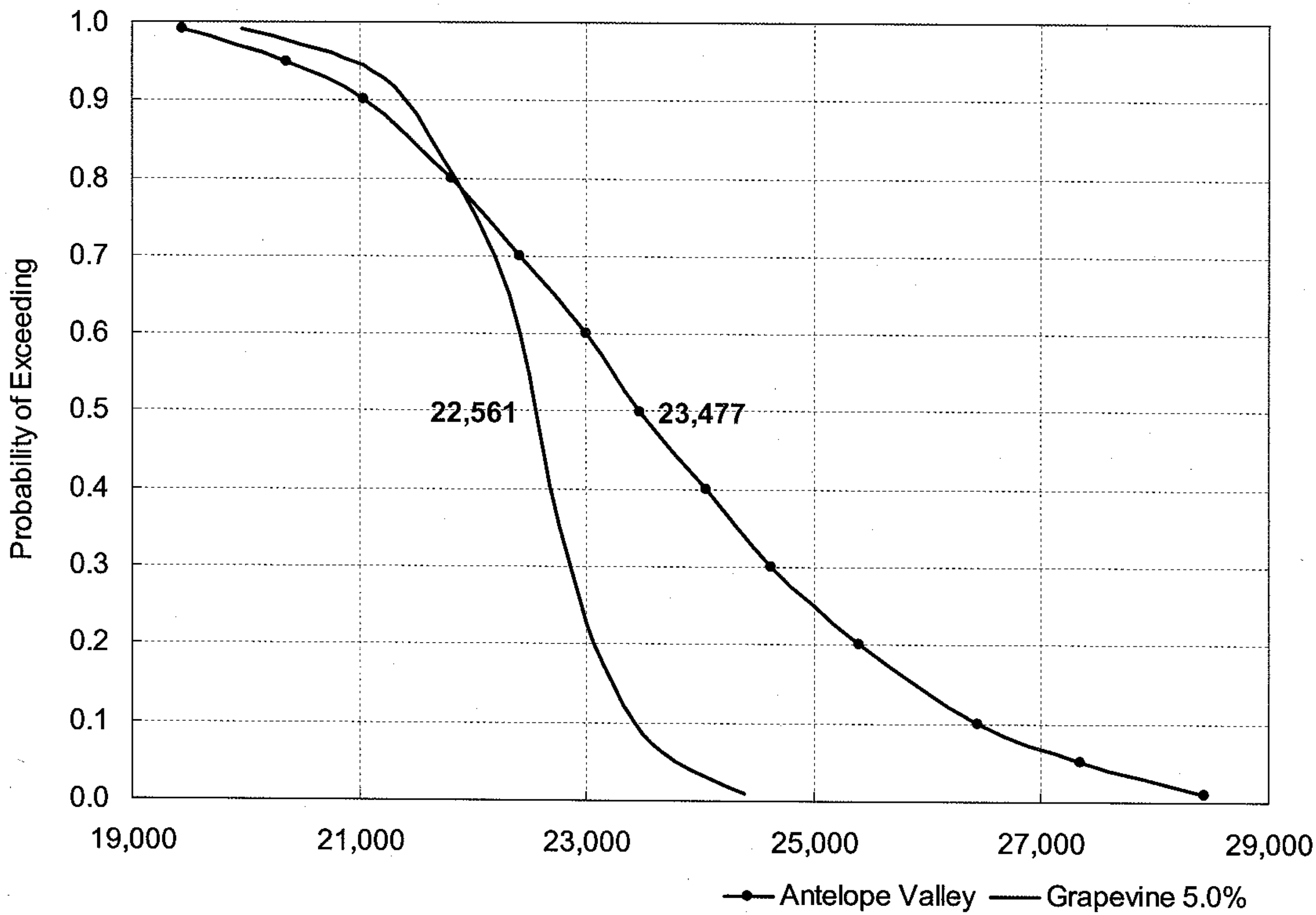
4.4.2 Benefit Cost Ratio

The Benefit Cost ratio also seems to indicate that the Antelope Valley is a better option for the State of California.

Table 16: Benefit Cost Ratio Estimates

	Mean	80% Confidence Interval	
		Lower Bound	Upper Bound
Antelope Valley Alignment	2.11	2.00	2.24
Grapevine Alignment	2.04	2.00	2.09
Percentage Difference	3.4%	0.0%	7.2%
Is the Difference Statistically Significant?	Yes		

Figure 7: Net Present Value Estimates, Antelope Valley vs. Grapevine



1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Probability of Exceeding
22,561
23,477
19,000
21,000
23,000
25,000
27,000
29,000
Antelope Valley
Grapevine 5.0%

4.4.3 Internal Rate of Return

The difference between the two alignments, when measured in terms of internal rate of return, is very small. As Table 17 indicates, the simulations show no statistically significant difference between the two investment alternatives.

Table 17: Internal Rate of Return Estimates

	Mean	80% Confidence Interval	
		Lower Bound	Upper Bound
Antelope Valley Alignment	8.79%	8.48%	9.10%
Grapevine Alignment (5%)	8.80%	8.63%	8.96%
Percentage Difference	-0.1%	-1.7%	1.6%
Is the Difference Statistically Significant?	No		

4.5 Summary of Findings and Conclusions

Table 18 summarizes the main findings of the analysis. The values for the Grapevine alignment are 1999 estimates by the Authority. They can be interpreted as mean expected (or "most likely") values.[19] Benefit and cost estimates for the Antelope Valley are derived from the benefit-cost analysis presented in this chapter. The values presented in the table may differ slightly from the values presented earlier in the chapter. The observed differences, however, do not affect the main conclusions of the study.

It is noteworthy that the Antelope Valley alignment offers greater economic returns to the state of California in spite of the possibility that the Grapevine alternative could generate about 3.9 percent lower capital and operating costs. As discussed below, lower costs under the Grapevine option would occur only if the savings associated with building 41 fewer route miles offset the expense of the extra 17 miles of tunneling. While considerable uncertainty attaches to the true nature of this trade-off, the Antelope Valley would nevertheless generate stronger economic returns under even the most optimistic assumptions regarding the cost of tunneling across the Grapevine.

[19] Even though they differ from the mean expected values as estimated by HLB risk analysis model.

Table 18: Comparative Evaluation of Alternative Alignments, Summary

	Antelope Valley	Grapevine	Difference
Passenger Revenue (1)	$9,709	$9,651	$58
User Benefits			
Intercity	$8,504	$8,519	-$15
Urban (2)	$350	$317	$33
Subtotal User Benefits	$8,854	$8,835	$18
Nonuser Benefits			
To Intercity Travelers (3)			
Airline Passenger Delay	$8,055	$7,765	$290
Aircraft Operating Delay	$4,422	$4,283	$139
Highway Delay	$3,772	$3,540	$232
Highway Accident Cost	$782	$780	$2
Highway Air Pollution	$103	$103	$0
Subtotal	$17,133	$16,471	$663
To Urban Travelers (4)			
Highway Delay	$9,817	$8,822	$995
Highway Accident Cost	$360	$326	$34
Highway Air Pollution	$48	$43	$4
Subtotal	$10,225	$9,192	$1,034
Subtotal Nonuser Benefits	$27,359	$25,662	$1,696
Total Benefits	$45,921	$44,149	$1,773
Costs			
Capital Costs	-$15,971	-$15,443	-$528
Operating and Maintenance Costs	-$6,329	-$6,015	-$314
Total Costs (5)	-$22,300	-$21,458	-$842
Net Present Value	$23,621	$22,690	$931
80% Confidence Interval			
Lower Bound	$21,123	$21,431	-$308
Upper Bound	$26,384	$23,385	$2,999

Notes: *(1) Does not include revenue from express commuter services*
(2) Benefits to HSR express commuters
(3) From diversion of intercity travelers to HSR
(4) From diversion of intercity travelers AND commuters to HSR
(5) Does not include cost of providing express commuter services

5. CONSTRUCTION COST AND SCHEDULE RISK

The accurate estimation of construction costs and potential construction delays is decisive when comparing two or more investment options. The purpose of this section is to introduce a framework for assessing and controlling for the risk associated with this estimation. The section borrows from previous work by HLB and from current estimates by Parsons Brinckerhoff.

According to recent reports prepared for the Authority, crossing the Tehachapi Mountains through the Antelope Valley would increase total construction costs by about $800 million relative to the least expensive Grapevine alternative (with 5% grades), and by about $240 million compared to the most expensive Grapevine option (with maximum grades of 3.5%). While the cost per mile is estimated to be less for the Antelope Valley, this alignment is also longer by approximately 40 miles. These extra miles of track construction would more than offset the difference in cost per mile. As explained below, the lower capital costs per mile are an indication of difficulties associated with the mountainous terrain in the Grapevine portion of the high-speed rail line.

5.1 Construction Cost Risk

The difference in total capital costs between the Antelope Valley and the cheapest Grapevine alternative (with grades up to 5%) is estimated at $798 million, or about 3% of total construction costs.[20] These estimates are based on preliminary engineering studies indicating a cost per mile of $37 million via the 5% Grapevine route and of $34 million via the Antelope Valley. The difference in cost per mile is taken to represent extra tunneling and related costs under the Grapevine option (Section 4.1.2). The difference also accounts for potentially higher environmental risk mitigation costs (Section 4.1.3).

In most studies, however, cost estimates are treated as fixed values or certainties. By relaxing the assumption of "certainty", it is possible to address additional issues and clarify the analysis. All engineering estimates contain uncertainties. In fact, most capital cost estimates include a contingency factor to account for underlying uncertainty and to protect against potential overruns. These contingency factors range from between ten to twenty five percent. A contingency amount is the appropriate way to reflect capital risks from the standpoint of capital budgeting, as it insures that funds are budgeted to cover potential overruns when a project is implemented. From the point of view of the overall benefit cost analysis of a project it is a reasonable, though conservative, method. It allows for the possibility of higher than expected costs, though not for the possibility of lower than expected costs.

The contingency approach is less appropriate for comparison between alternatives, especially when the difference in cost between two options is low relative to the uncertainties surrounding each alternative. In that case, a risk analysis (which considers the probability of higher and

[20] Parsons Brinckerhoff, July 1999: the difference is $798 million assuming 5% grades for the Grapevine Alignment; $237 million assuming 3.5% grades.

lower costs for each alternative, independently) can determine the probability of total costs being significantly different across alternatives.

As shown in Sections 4.1.1 through 4.1.3, there are different degrees of risk attached to the two competing alignments.

5.1.1 Gradient Issues

Construction plans for the Grapevine segment of the HSR line are based on the use of 5% grades to limit the amount of expenditures necessary to cross fault lines at grade. According to Parsons Brinckerhoff 's estimates, using grades up to 3.5% would increase the cost of the Grapevine segment by about $560 million. Under this alternative, the cost difference between the Antelope Valley and the Grapevine would be reduced from $798 million to only $237 million, less than 1% of total construction costs.

There is widespread belief in the technical community that the recommended technology will work at 5% grades, although this has not been attempted in conditions similar to those which will be found in California. If technical problems are encountered, trains will still be able to operate on the 5% gradients. However, operating modifications would then be necessary. These modifications would involve lower average speeds, which might offset the gain in time from the shorter alignment. Table 19 below summarizes Parsons Brinckerhoff 's findings concerning the pros and cons of a 5% grade alignment.

Table 19: Pros and Cons of the 5% Gradient Option

Pros	Cons
Manufacturers claim 5% capability	5% Not tested in revenue service
Significant reduction in tunneling and capital cost with 5%	Higher energy usage and reduced speeds with 5% grades
	5% limits freight operations
	Sustained grades required

Source: Parsons Brinckerhoff, July 1999

The present study compares, conservatively, the cheaper 5% Grapevine alternative to the Antelope Valley alignment. Simulation results with the 3.5% Grapevine option are also briefly discussed.

5.1.2 Tunneling Issues

While the Grapevine option would require some 40 fewer miles of track construction than the Antelope Valley alignment, this advantage would come at the cost of 17 more route-miles of tunneling through a fault-riddled section of the Tehachapi Mountains. Tunneling is viewed, in the technical community, as one of the cost components most sensitive to uncertainties, delays, and overruns. In other words, choosing the Grapevine alignment would significantly increase the risk of budget overruns and construction delays relative to the Antelope Valley choice. In fact, crossing the Tehachapi Mountains through the Grapevine route would be the costliest (on a per-mile basis) and riskiest type of civil construction that would be encountered on the entire project.

5.1.3 Environmental Issues

Environmental impacts, as noted in Parsons Brinckerhoff 's feasibility reports, are expected to be greater for the Grapevine alignment. The Grapevine route would indeed go through areas of wilderness and regions used heavily for recreational purposes. These environmental impacts must be fully mitigated. The estimated per mile cost for each alignment reflect these mitigation costs. Because environmental mitigation costs are often much more difficult to predict than other construction costs, there is a strong argument for greater uncertainty surrounding the costs of the Grapevine alternative than for the Antelope Valley. The large contingency amount for the whole project makes this difference insignificant from the point of view of the entire project. However, it is highly significant when comparing the two alignments.

5.1.4 Risk Analysis of Construction Costs

In order to reflect uncertainty, risk analysis uses estimates of probability ranges. Parsons Brinckerhoff 's projected costs per mile were used as median values for the risk analysis summarized below. Tunneling costs being more "risky" (on the up-side), the probability range - or distribution - for the Grapevine cost per mile variable is assumed more (right) skewed than the corresponding distribution for the Antelope Valley.

The risk analysis assumptions, summarized in Table 20 below, are based upon Parsons Brinckerhoff 's projected costs (inclusive of a 25% contingency amount) for the Tehachapi segment and upon the miles of tunneling required under the alternative alignments.

Table 20: Tunneling and Construction Cost, Antelope Valley vs. Grapevine

	Grapevine 3.5%	Grapevine 5.0%	Antelope
Capital Costs ($1999 Million)	4,615	4,054	4,852
Cost per Mile of Tunneling	60.0	60.0	60.0
Miles of Tunneling	28.0	14.0	11.0
Lower 10%	-25%	-25%	-25%
Upper 10%	50%	50%	50%

An average cost per mile of tunneling of $60 million (expressed in dollars of 1999) was assumed. The high end of the probability range for all three options was calculated by assuming a 50% cost overrun for tunneling. The 10% upper value was derived as follows:

10% Upper Value = PB Total Projected Cost + 50% of Total Tunneling Cost

The low end of the probability range was estimated by assuming that tunneling cost could be 25% less than projected; in other words:

10% Lower Value = PB Total Projected Cost - 25% of Total Tunneling Cost

The outcome of these calculations is presented in Table 21 below. The values in the table serve as inputs for estimating total construction costs. Note that construction costs for the other segments (i.e. other than Tehachapi crossing) are assumed fixed: risk analysis techniques are applied to the Bakersfield - Los Angeles segment only.

Table 21: Risk Analysis Assumptions for Tehachapi Crossing Construction Costs

	Median	Lower 10%	Upper 10%
Tehachapi Crossing Construction Cost ($1999 Million)			
Antelope Valley Alignment	4,852	4,687	5,182
Grapevine Alignment (3.5%)	4,615	4,195	5,455
Difference	*237*	*492*	*-273*
Grapevine Alignment (5.0%)	4,054	3,844	4,474
Difference	*798*	*843*	*708*

Table 21 indicates a median incremental cost of about $800 million for the Antelope Valley alignment under the 5.0% gradient scenario, and a median incremental cost of only $237 million under the 3.5% scenario. In other words, along with when considering the risks highlighted above, there is a 50% probability that choosing the Antelope Valley alignment would raise total construction costs by about $800 million (a 3% increase) relative to the less expensive Grapevine alternative. The expected value of the additional cost of routing via Antelope Valley (shown in Table 22), when the above risks are considered, however, is about $780 million compared to the least expensive Grapevine alternative but only $150 million compared to the most expensive Grapevine option.[21]

Table 22: Risk Analysis of Total Capital Costs, $1999 Million

	Mean	80% Confidence Interval	
		Lower Bound	Upper Bound
Antelope Valley Alignment	26,284	26,557	26,063

[21] Differences between median and mean estimates are due to the shape of the distributions. Since the distribution for the 3.5% Grapevine costs is heavily right-skewed (to account for up-side risk), the mean expected cost for this alignment is above the median estimate. It follows that the difference between the two alignments is smaller when estimated at the mean.

Grapevine Alignment (3.5%)	26,134	26,830	25,571-
Percentage Difference	0.57%	-1.02%	1.92%
Is the Difference Statistically Significant?	No		
Grapevine Alignment (5.0%)	25,501	25,849	25,221
Percentage Difference	3.07%	2.74%	3.34%
Is the Difference Statistically Significant?	Yes		

Figure 8 presents the decumulative probability distributions for all three alignments. The figure shows in particular that there is a non-zero probability (about 25%) that, other things the same, the most expensive Grapevine alternative (3.5%) would actually be more expensive than the Antelope Valley alternative. As shown in the graph, given the sizeable excavation and tunneling risks, the 3.5% Grapevine option could become as much as $1 billion more expensive than the Antelope Valley alternative. This outcome, however, is highly unlikely (less than 1% probability).

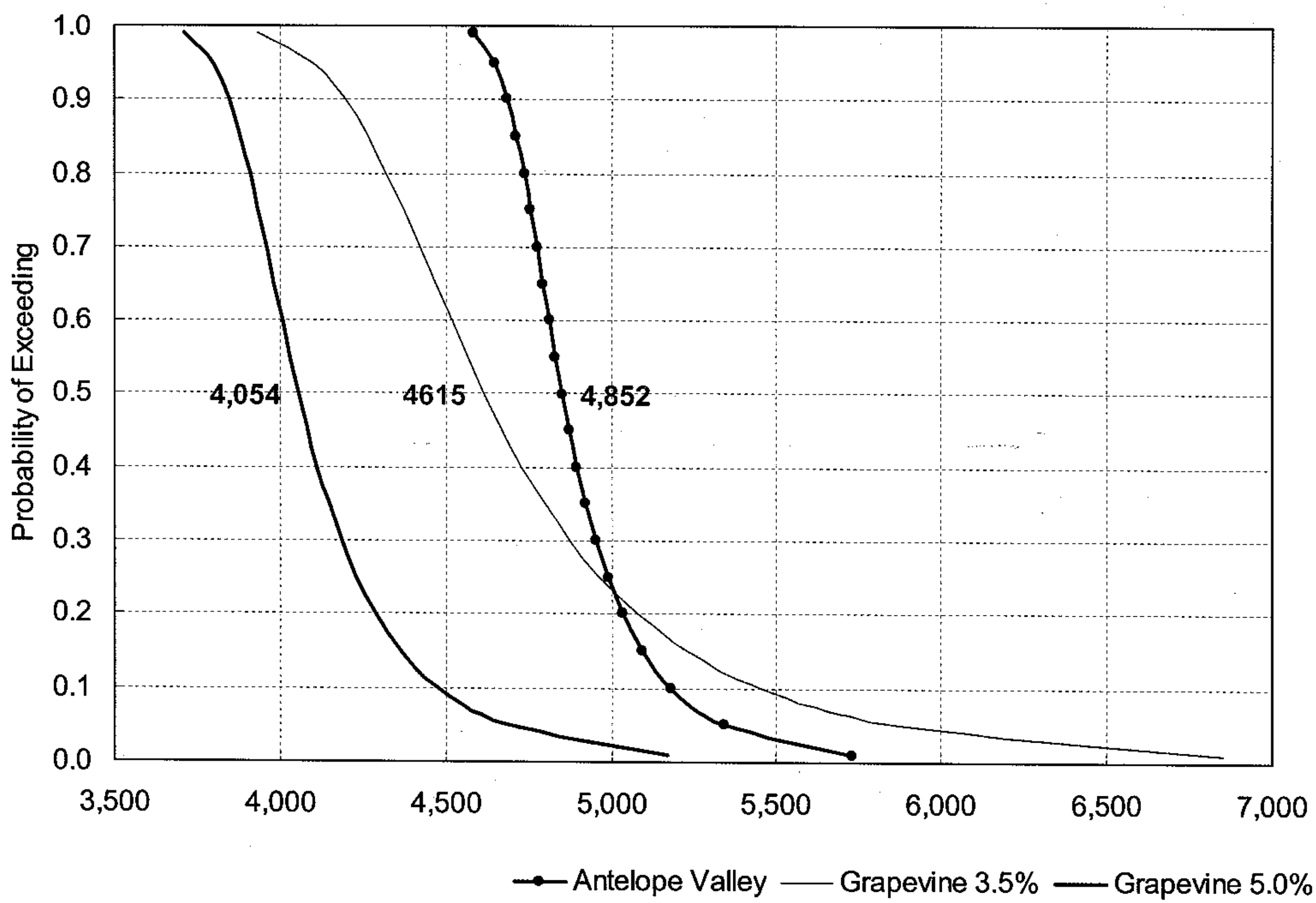
5.2 Schedule Delay Risk

Excavation and tunneling also bring schedule risk. Unexpected or unplanned additions to earthwork, sub-grade construction and tunneling are the principal causes of slippage against project schedules. The Grapevine option thus presents a substantially greater risk of project schedule delay than does the Antelope Valley alternative.

5.3 Summary of Findings and Conclusions

Apart from general ridership and revenue risk, the principal business risks facing the California High-Speed Rail Authority pertain to construction period capital outlay and project schedule. Risk analysis of the engineering factors that underlie the choice between the Antelope Valley and the Grapevine alignment options suggest that both risks are minimized under the Antelope Valley choice.

Figure 8: Capital Cost Risk along the Tehachapi Crossing, 1999 $Millions



6. CONCLUSIONS

Table 23 summarizes the main findings of this report. The Antelope Valley alignment appears clearly as the value-for-money maximizing alternative. It would indeed generate between $1.0 and $1.8 billion worth of revenue and benefits (e.g. time savings, safety savings, environmental benefits and incremental economic growth) net of costs, in excess of what the competing alignment would produce. This would represent about $90 to $170 worth of "benefits" to each of the 10.4 million households[22] living in California today.

Table 23: Comparative Evaluation of the two Alignments, Summary

	Antelope Valley	Grapevine	Difference
Passenger Revenue	$9,709	$9,651	$58
Total User Benefits	$8,854	$8,835	$18
Total Nonuser Benefits	$27,359	$25,662	$1,696
Total Benefits	$45,921	$44,149	$1,773
Total Costs	-$22,300	-$21,458	-$798
Net Present Value	$23,621	$22,690	$974
Long Run Economic Development due to the Antelope Valley alignment	$818	$0	$818

Present Value of $1999 Million

[22] Based on 1990 Census.

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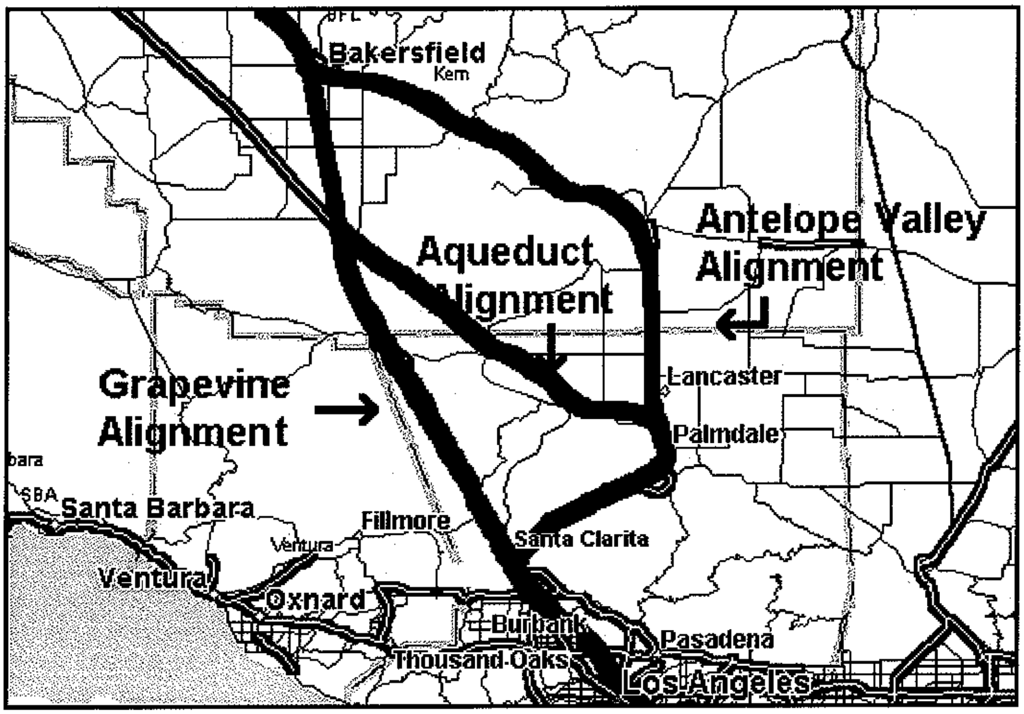
APPENDIX 1: A MAP OF THE ANTELOPE VALLEY AND THE GRAPEVINE ALIGNMENTS



APPENDIX 2: INTERCITY RIDERSHIP AND REVENUE FORECASTS

The following tables summarize the fiscal year 2020 ridership and revenue projections developed by the Authority.

Table 24: 2020 Intercity Ridership Projections, Number of Trips

FROM	TO	VHS		MAGLEV	
		Antelope	Grapevine	Antelope	Grapevine
Los Angeles	San Francisco	10,149,127	11,269,050	14,125,204	14,981,816
Los Angeles/San Francisco	Valley	5,120,355	5,233,698	5,692,197	5,799,715
Valley	Valley	783,805	768,334	843,067	824,702
Sacramento	Los Angeles	3,084,488	3,384,964	4,082,289	4,267,865
Sacramento	San Francisco	1,690,169	1,690,169	2,020,286	2,020,286
San Diego	Los Angeles	5,426,904	5,304,220	5,877,854	5,737,451
San Diego	San Francisco	2,016,041	2,260,634	3,284,302	3,584,847
Other		2,015,444	2,091,034	2,504,924	2,597,982
Total		**30,286,333**	**32,002,103**	**38,430,123**	**39,814,664**

Source: "Forecast Summary by O/D Segment", Memorandum by the California High-Speed Rail Authority, January 5, 2000

Table 25: 2020 Intercity Passenger Revenue Projections, $1999

FROM	TO	VHS		MAGLEV	
		Antelope	Grapevine	Antelope	Grapevine
Los Angeles	San Francisco	320,519,503	347,881,522	453,962,454	469,025,604
Los Angeles/San Francisco	Valley	122,993,128	129,861,992	137,816,002	138,072,777
Valley	Valley	18,154,513	17,721,242	19,718,605	19,201,292
Sacramento	Los Angeles	97,314,215	104,217,668	130,260,591	132,455,748
Sacramento	San Francisco	40,782,380	40,782,380	49,718,703	49,718,703
San Diego	Los Angeles	127,670,556	124,658,232	139,383,626	135,891,950
San Diego	San Francisco	67,535,678	74,304,949	113,472,630	121,263,656

Other			53,370,020	48,749,572	69,037,786	70,901,146
Total			**848,339,993**	**888,177,557**	**1,113,370,397**	**1,136,530,876**

Source: "Forecast Summary by O/D Segment", Memorandum by the California High-Speed Rail Authority, January 5, 2000

APPENDIX 3: EXPRESS COMMUTER RIDERSHIP FORECASTS

The tables below summarize the Authority Express Commuter Ridership forecasts.[9]

Table 26: Year 2020 Express Commuter Ridership and Revenue Projections

ALIGNMENTS	Annual Ridership	Passenger Revenue ($1999)	Route Description
SAN DIEGO AREA			
COAST	388,000	$2,819,000	Oceanside to downtown San Diego
SR52	312,000	$2,264,000	Temecula to downtown San Diego
STADIUM	220,000	$1,495,000	Temecula to Qualcomm Stadium
TOTAL	920,000	$6,578,000	
LOS ANGELES AREA			
ORANGE COUNTY	779,000	$5,402,000	Oceanside to Union Station
RIVERSIDE COUNTY	3,545,000	$28,042,000	Temecula to Union Station
LOS ANGELES COUNTY	4,275,000	$32,131,000	Palmdale to Union Station
TOTAL	8,599,000	$65,575,000	
SAN FRANCISCO BAY AREA			
ALTAMONT PASS	2,282,000	$17,171,000	Modesto / Stockton to San Jose / San Francisco
PACHECO PASS	3,272,000	$22,728,000	Los Banos to San Jose and San Francisco
EAST BAY	880,000	$6,881,000	Los Banos to San Jose and West Oakland
TOTAL	6,434,000	$46,780,000	
GRAND TOTAL	**15,953,000**	**$118,933,000**	

Table 27: Los Angeles County Express Commuter Ridership and Revenue Projections

ROM	TO	Year 2020 Projections			Present Value of Total Passenger Revenue**
		Daily Inbound Trips	Total Annual Ridership	Passenger Revenue *	
almdale	Union Station	3,280	1,640,000	$14,850,000	$162,572,812
anta Clarita	Union Station	4,280	2,140,000	$14,438,000	$158,062,374

urbank	Union Station	990	495,000	$2,843,000	$31,124,209
otal		**8,550**	**4,275,000**	**$32,131,000**	**$351,759,395**

*Notes: * In 1999 Dollars; ** Over the period 2017 - 2050, under the conservative assumption that Express Commuter Revenue on the Los Angeles County alignment grows at the same rate as Total Intercity Revenue.*

The study indicates that Palmdale, with $14.85 million annually, would be the largest revenue-generating station for express commuter rail, followed by Temecula and Santa Clarita.[23]

[23] Charles River Associates Inc., "Ridership and Revenue Analysis for High Speed Ground Transportation in California, Task 6 Report: Express Commuter Ridership and Revenue Forecasts on HSR Alignments," June 1999.

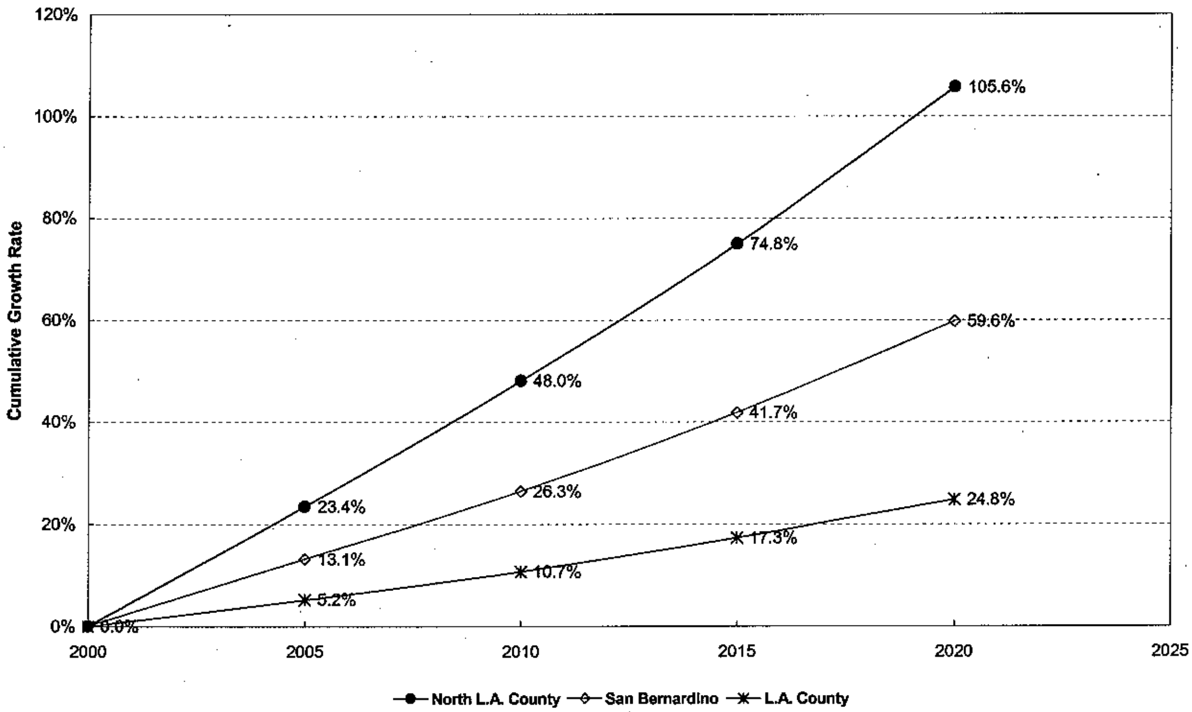
APPENDIX 4: SUB-REGIONAL POPULATION AND EMPLOYMENT GROWTH PROJECTIONS 2000-2020

Table 28: SCAG Sub-Region Population Projections

County	Sub-Region	2000	2005	2010	2015	2020
Imperial	IVAG	148,900	171,800	207,300	240,800	280,200
Los Angeles	North LA County	590,200	728,500	873,600	1,031,700	1,213,400
Los Angeles	LA City	3,845,300	4,051,200	4,298,900	4,578,700	4,890,900
Los Angeles	Arroyo Verdugo	556,800	578,000	604,200	647,400	684,000
Los Angeles	SGVCOG	1,566,700	1,624,400	1,673,500	1,728,700	1,805,200
Los Angeles	Westside Cities	233,600	238,000	242,400	248,200	253,100
Los Angeles	South Bay Cities Association	857,700	872,200	884,600	902,900	925,600
Los Angeles	Gateway Cities COG	2,086,500	2,149,700	2,196,900	2,275,500	2,368,600
Los Angeles	Las Virgenes, Malibu, Conejo COG	81,700	87,800	94,600	100,400	108,300
Orange	Orange COG	2,859,100	3,005,700	3,105,500	3,165,400	3,244,800
Riverside	WRCOG	1,315,300	1,564,900	1,814,100	2,033,900	2,264,000
Riverside	CVAG	372,300	412,100	450,900	497,600	551,800
San Bernardino	SANBAG	1,772,700	2,005,400	2,239,600	2,512,800	2,829,800
Ventura	Ventura COG	712,800	745,000	804,300	861,700	932,300
TOTAL SCAG		**16,999,000**	**18,234,000**	**19,491,000**	**20,826,000**	**22,352,000**

Source: SCAG, 1998 RTP Adopted Forecast, April 1998

Figure 9: SCAG Cumulative Population Growth Projections, 2000 - 2020



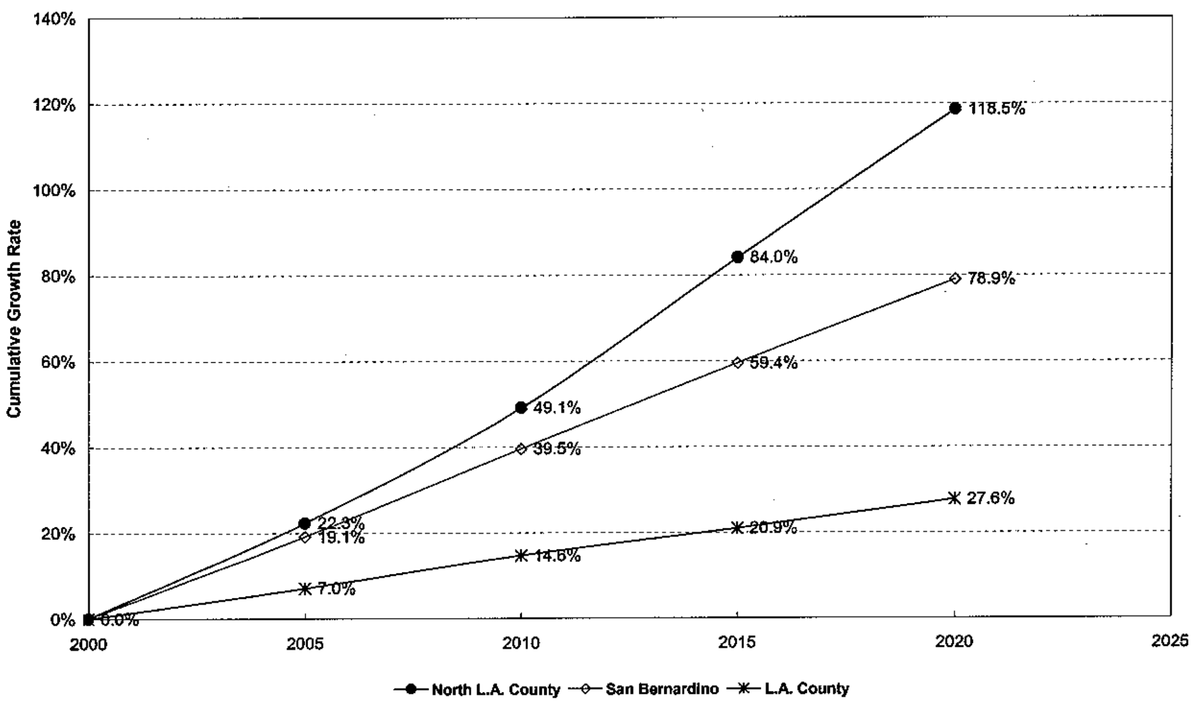
120%
100%
80%
60%
40%
20%
0%
Cumulative Growth Rate
2000
2005
2010
2015
2020
2025
105.6%
74.8%
48.0%
23.4%
0.0%
59.6%
41.7%
26.3%
13.1%
24.8%
17.3%
10.7%
5.2%
North L.A. County
San Bernardino
L.A. County

Table 29: SCAG Sub-Region Employment Projections

County	Sub-Region	2000	2005	2010	2015	2020
Imperial	IVAG	62,200	69,200	74,900	82,200	89,900
Los Angeles	North LA County	190,800	233,300	284,400	351,100	416,900
Los Angeles	LA City	1,851,600	1,953,000	2,038,300	2,121,000	2,209,300
Los Angeles	Arroyo Verdugo	316,100	345,000	374,600	388,300	410,200
Los Angeles	SGVCOG	586,200	635,000	695,600	739,200	776,300
Los Angeles	Westside Cities	237,800	246,500	261,700	271,400	285,100
Los Angeles	South Bay Cities Association	450,200	478,300	500,500	524,600	554,400
Los Angeles	Gateway Cities COG	879,300	938,900	1,017,700	1,063,300	1,110,400
Los Angeles	Las Virgenes, Malibu, Conejo COG	45,700	48,200	50,200	52,700	55,300
Orange	Orange COG	1,381,700	1,550,700	1,717,400	1,882,600	2,116,600
Riverside	WRCOG	366,700	464,800	563,200	644,900	740,300
Riverside	CVAG	149,200	164,900	183,800	203,900	220,400
San Bernardino	SANBAG	617,000	734,800	860,700	983,400	1,103,600
Ventura	Ventura COG	306,600	343,200	394,800	438,200	485,600
TOTAL SCAG		**7,441,000**	**8,206,000**	**9,018,000**	**9,746,000**	**10,574,000**

Source: SCAG, 1998 RTP Adopted Forecast, April 1998

Figure 10: SCAG Cumulative Employment Growth Projections, 2000-2020



APPENDIX 5: HIGH-SPEED RAIL BENEFITS TO FREIGHT SHIPPERS

As explained in Parsons Brinckerhoff 's memorandum "Corridor Evaluation - Freight Issue" dated July 13, 1999, the California HSR passenger services could be supplemented with two types of freight services: (1) small package and light container freight services carried on special cars designed to be integrated with passenger trains and (2) special medium weight freight services carried on freight-only trains.

HLB believes that a high-speed rail link to the Palmdale airport would be particularly valuable for shippers in the Antelope Valley area and the State of California. Recent estimates by the Southern California Association of Governments (SCAG) indeed predict a severe shortage of air-cargo capacities at regional airports by 2020. By then, the Association's forecasts show a staggering 8.9 million annual tons of air cargo shipped in and out of Southern California. In 1995, 3 million tons were shipped in and out of the region. In this context, Palmdale could become a viable alternative to the already congested Los Angeles Airport (LAX) for cargo operations. A high-speed rail system connecting LAX, the San Fernando Valley, Santa Clarita and the Antelope Valley could help in this process.[24]

The appendix is structured as follows. Some statistics on freight movement in California are presented in the first section. The second section summarizes HLB's methodology for deriving user benefits associated with HSR freight services. The last section presents and discusses the estimates. Note that freight shippers who elect not to use high-speed rail for their shipment might also benefit from the implementation of a high-speed train in the State of California. One may expect, in particular, that reductions in highway or airport congestion would facilitate the movement of goods and mail on existing modes. The benefits associated with these movements, though probably significant, are not included in this study.

Freight in the State of California

[24] Freight shippers would "use" high-speed rail in conjunction with air in this framework.

Freight statistics from the U.S. Census Bureau's commodity flow survey are summarized in the tables below.

Table 30: Shipment Characteristics by Mode of Transportation, 1997

Mode of Transportation	Value ($ million)	Share	Tons (thousands)	Share	Ton-Miles (millions)	Share
All Modes	802,192	100.0%	778,805	100.0%	133,347	100.0%
Single Modes	614,007	76.5%	742,411	95.3%	106,188	79.6%
Truck	542,698	67.7%	624,261	80.2%	83,265	62.4%
Rail	7,059	0.9%	14,041	1.8%	15,860	11.9%
Water	NA	NA	NA	NA	NA	NA
Air (includes truck and air)	46,838	5.8%	1,138	0.1%	2,005	1.5%
Pipeline	14,127	1.8%	62,990	8.1%	NA	NA
Multiple Modes	141,553	17.6%	6,329	0.8%	11,484	8.6%
Parcel, US Postal Service or Courier	134,569	16.8%	2,910	0.4%	3,508	2.6%
Truck and Rail	5,361	0.7%	2,540	0.3%	5,452	4.1%
Truck and Water	1,616	0.2%	869	0.1%	2,507	1.9%
Rail and Water	-	-	-	-	-	-
Other Multiple Modes	NA	NA	NA	NA	NA	NA
Other and Unknown Modes	46,632	5.8%	30,066	3.9%	15,675	11.8%

Source: "Commodity Flow Survey," U.S. Census Bureau, 1997 Economic Census, Dec.9, 1999
Notes: Detail may not add to total because of rounding; "-" represents data cell equal to zero or less than 1 unit of measure; NA data do not meet publication standards.

Table 31: Shipment Characteristics by Distance Shipped, 1997

Distance Shipped	Value ($ million)	Share	Tons (thousands)	Share	Ton-Miles (millions)	Share
Total	802,192	100.0%	778,805	100.0%	133,347	100.0%
Less than 50 miles	324,047	40.4%	586,259	75.3%	13,261	9.9%
50 to 99 miles	65,733	8.2%	54,542	7.0%	5,085	3.8%
100 to 249 miles	59,520	7.4%	49,483	6.4%	9,402	7.1%
250 to 499 miles	76,811	9.6%	39,256	5.0%	15,936	12.0%
500 to 749 miles	25,250	3.1%	10,933	1.4%	8,173	6.1%
750 to 999 miles	25,525	3.2%	6,604	0.8%	7,422	5.6%
1,000 to 1,499 miles	44,751	5.6%	6,838	0.9%	10,798	8.1%
1,500 to 1,999 miles	70,353	8.8%	10,573	1.4%	23,312	17.5%
2,000 miles or more	110,203	13.7%	14,316	1.8%	39,958	30.0%

Source: "Commodity Flow Survey," U.S. Census Bureau, 1997 Economic Census, Dec.9, 1999

Methodology

For the purpose of the analysis, distinction between two markets:

- Intra-State freight movements: truck with distance shipped less than 250 miles.
- Movements via California's airports: air (including truck and air).

For both alignments, freight user benefits have been estimated on the basis of freight statistics (see first section) and HLB assumptions, as summarized in Table 32 below.

Parsons Brinckerhoff 's engineers stress that both freight services would operate on 3.5% grades. However, the use of 5.0% grades (i.e. the choice of the least expensive 5.0% Grapevine option) would limit freight services to mail and very light packages. For this reason …

Table 32: Freight, HSR User Benefits, Assumptions

Freight Movements ...	Intra-State (Truck Only)	Via California's Airports
Shipment Originating in CA, $Million, 1997 *	542,698	46,838
Percentage Less than 250 Miles	56%	--
Diversion to HSR	5%	10%
User Benefits (% of Shipment Value) **		
Cost Savings	2.00%	2.00%
Quality of Service	1.00%	1.00%
Growth from 1997 to 2020	10%	10%
Growth from 2020 to 2050	Grows with Ridership Projections	

* *Source: "Commodity Flow Survey," U.S. Census Bureau, 1997 Economic Census, Dec.9, 1999*
** *HLB Assumption*

HSR Benefit Estimates

Given the opportunity offered by a link to available air-cargo capacities under the Antelope Valley alternative, together with the limitations highlighted by Parsons Brinckerhoff regarding 5% grades for the Grapevine alignment[25], the expected benefits from freight operations are significantly larger under the Antelope Valley option. This is shown in the table below.

Table 33: Freight, HSR User Benefits, Most Likely Value

User Benefits	Antelope Valley	Grapevine 3.5%	Grapevine 5.0%
Intra-State Truck Movements			
Cost / Time savings			
Quality of Service			
Total Benefits			
Via California's Airports			
Cost / Time savings			

[25] These limitations have been translated into a 5% decrease in the benchmark Year 2020 benefit estimates for the Grapevine option relative to the Antelope Valley.

Quality of Service			
Total Benefits			
Grand Total			

All estimates in Present Value, Millions of 1999 Dollars

To sum up, the analysis clearly shows that choosing the Palmdale alternative would yield significant benefits to freight shippers in California. These benefits would be significantly larger than under the competing alignments. They would be larger than under the 5.0% Grapevine route because 5.0% grades preclude the shipment of medium-weight packages. They would also be significantly larger than under the 3.5% Grapevine option because the Palmdale route would offer a direct link to vast and growing airport facilities.

APPENDIX 6: A MAP OF THE ANTELOPE VALLEY REGION

Figure 11: Los Angeles 60 Mile Circle

Source: http://www.aveconomy.org/region/cities.html